Conducting 3D-carbon scaffolds induce spontaneous differentiation of human neural stem cells and measure neurotransmitter release in real-time

Amato, Letizia; Schulte, Lars; Heiskanen, Arto; Boisen, Anja; Keller, Stephan Sylvest; Ndoni, Sokol; Emnéus, Jenny

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Tailoring the structure and the properties of pyrolysed carbon electrodes

Letizia Amato, Lars Schulte, Arto Heiskanen, Anja Boisen, Stephan S. Keller, Sokol Ndoni, Jenny Emnéus

Technical University of Denmark, Department of Micro- and Nanotechnology (leta@nanotech.dtu.dk)

Here we present a study with pyrolysed carbon derived from the photoresist SU-8, polystyrene (PS) and polystyrene-blockpolydimethylsiloxane (PS-PDMS) copolymers (Fig. 1) to evaluate them as electrode material. XPS analysis showed that pyrolysed PS-PDMS contains an atomic percentage of 29% silicon. The silicon content may be a limiting factor for obtaining high-conductive structures due to lower carbon content (19%) compared to PS (96%) and SU-8 (98%), but at the same time the silicon is functioning as support for the 3D structure (fig. 1B). Raman spectra of pyrolysed carbon derived from SU-8 photoresist, revealed the presence of the so called D and G peaks (Fig. 1C), indicating that both amorphous and graphitic regions are contributing. The peak intensity ratio of the D and G peaks varies with the microstructural disorder of the carbon matrix[1]. From the Raman spectra, the calculated I_D/I_G is higher for pyrolysed films of PS-PDMS (I_D/I_G = 1.1) compared to SU-8 and PS (I_D/I_G = 1), indicating higher microstructural disorder of pyrolysed PS-PDMS. Additionally, the standard rate constant for electron transfer (k^0) was determined from the experimental ΔE_p with the method of Nicholson[2] (table 1). The slower electron transfer kinetics of PS-PDMS compared to PS and SU-8 films may be related to its lower carbon content, as well as to its higher microstructural disorder .

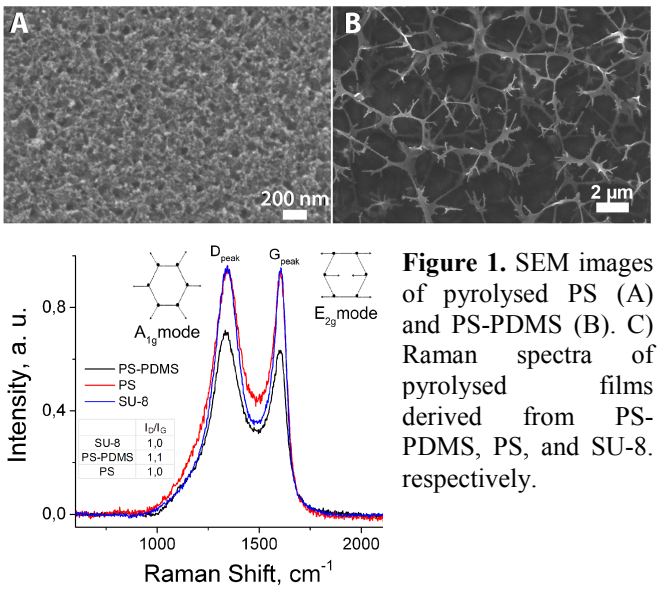

Figure 1. SEM images of pyrolysed PS (A) and PS-PDMS (B). C) Raman spectra of pyrolysed films derived from PS-PDMS, PS, and SU-8. respectively.

Table 1. k^0 values calculated from the experimental ΔE_p of the CVs obtained in 1mM $Ru(NH_3)_6^{3+/2+}$, scan rate 10 mV s^{-1}.

Electrode material	ΔE_p (mV)	k^0 (cm s^{-1})
PS-PDMS	109	8,0E-02
PS	78	3,3E-01
SU-8	92	1,2E-01

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2. Nicholson, S. R. Theory and application of cyclic voltammetry for measurement of electrode reaction kinetics. *Analytical chemistry* **37,** 1351–1355 (1965).